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ABSTRACT

Directors and faculty members representing undergraduate environmental science/studies, in conjunction with the American Institute of Biological Sciences generated this report on the current status of and future prospects in undergraduate environmental science (ES) education. Despite their varied backgrounds and the diverse nature of their programs and institutions, they concurred on the following issues: mission and impact, curriculum, program structure, students, administration, and funding. The conclusions of the report are as follows: (1) ES programs have had a national impact, with respect to general awareness of environmental issues and in the training of professionals with the expertise to work on solving complex, cross-disciplinary environmental problems; (2) ES graduates must have an interdisciplinary perspective, with adequate depth in one of the technical areas, as well as a grasp of policy and ethics; (3) ES graduates need to have analytical and problem-solving skills, computer skills, critical thinking skills, and both oral and written communication skills; (4) ES programs should provide experiential activities through field work, internships, or research experiences; (5) strong faculty and administrative support is integral to the effectiveness of the interdisciplinary approach; and (6) increased federal funding is small relative to the scope of environmental problems and a significant barrier to program development. Four models of administrative arrangements are described and evaluated for effectiveness as support structures for interdisciplinary programs such as ES. These include a traditional departmental status, an interdisciplinary program structure with contractual arrangements for teaching responsibilities, interdisciplinary program structure with voluntary faculty participation, and programs housed within existing departments. (MCO)

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American Institute of Biological Sciences

Report of the Workshop on

UNDERGRADUATE ENVIRONMENTAL SCIENCE EDUCATION

Held in conjunction with the

42nd AIBS ANNUAL MEETING
OF SCIENTIFIC SOCIETIES

SAN ANTONIO, TEXAS
7-8 AUGUST 1991

Judith S. Weis, Coordinator

U.S. DEPARTMENT OF EDUCATION
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DEDICATION

This report is dedicated to the memory of Dr. William Odum, an exemplary environmental scientist and developer of an outstanding environmental science department at the University of Virginia. An original member of the steering committee for this workshop, his untimely death is a great loss for the environmental science community.

ACKNOWLEDGMENTS

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The views expressed in this report are those of the coordinator and the individual participants. They do not necessarily reflect the official positions of either the sponsoring organizations or the employers of any of the participants.

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EXECUTIVE SUMMARY

Directors and faculty of undergraduate environmental science (ES) programs met for two days to share information and make recommendations regarding the development of such programs. They concluded that ES programs have had a national impact, in terms of our awareness of environmental issues and in the training of professionals with the expertise to work on solving complex cross-disciplinary environmental problems.

The group made a number of recommendations regarding the skills and knowledge that graduates from such programs should have. ES graduates should have an interdisciplinary perspective in order to see the "big picture," but must also have adequate depth in one of the technical areas, as well as a grasp of policy and ethics. Environmental Science graduates ought to have analytical and problem-solving skills, computer skills, critical thinking, and both oral and written communications skills. These may be acquired within ES courses, as well as from other departments. This will require students to have rigorous course schedules and careful advisement by faculty. ES programs should provide experiential activities through field work, internships, or research experiences.

With regard to the administrative arrangements for such interdisciplinary programs within the institution, there are a number of arrangements that can be effective. In order for any program to succeed, it must have strong faculty and administrative support. If an independent department does not exist, a program director should minimally have autonomy and a separate operating budget. Mechanisms must be in place to protect program faculty from bias against interdisciplinary work when promotion and tenure decisions are made.

Funding from the federal government has been small relative to the scope of environmental problems and the needs for trained professionals to solve them. Federal support is greatly needed to build strong environmental science programs with modern scientific equipment. The lack of federal leadership in this area has been a significant barrier to program development. The new National Academy of Sciences committee that has been established to look into the state of funding for research in the environmental sciences should also consider the state of federal support for the undergraduate education needed to produce environmental scientists.

INTRODUCTION

A group of directors and faculty representing undergraduate environmental science/studies programs from throughout the U.S., gathered in San Antonio, TX Aug. 7-8, 1991. Their purpose was to exchange ideas, discuss issues and develop recommendations for the future of these programs in U.S. colleges and universities. Although the status of environmental programs has been the subject of recent articles (e.g., *The Environmental Professional* vol. 9 (3) Special Issue: Focus on Environmental Studies, 1987; Weis, 1990, Envir. Sci. Tech. 24:1116-1121) there has not previously been such a forum for exchange of ideas among ES directors. The workshop was held in conjunction with the American Institute of Biological Sciences meetings, but attendees represented a wider range of disciplines beyond the biological sciences. They came from private liberal arts colleges and universities, comprehensive state institutions, and major research universities. Despite their varied backgrounds and the diverse nature of their programs and institutions, they found much in common and substantial agreement on many of the issues of importance.

The first morning of the two-day workshop commenced with presentations from individuals representing potential employers of environmental science graduates, including government agencies, the private sector, and public interest environmental groups. There was considerable agreement that ideal employees need a solid foundation in the sciences, but also need excellent communications and problem-solving skills as well. Their remarks are summarized in the appendix to this report.

Following the panel discussion, workshop participants divided into working groups to brainstorm and deliberate on certain questions and issues, led by members of the steering committee, Drs. John Lemons (University of New England), Gary Miller (University of North Carolina, Asheville), Robert Wenger (University of Wisconsin - Green Bay), Gordon Godshalk (Alfred University), and Richard Foust (Northern Arizona University). The following pages constitute the results of their deliberations.

MISSION AND IMPACT

As educators, we have a commitment to educate both the general student population and environmental science majors who will become career professionals. The environmental science/environmental studies programs in existence have made significant progress in addressing both of these needs. For example, most universities currently offer an "Environmental Issues" or "Humans and the Environment" course, and many offer an additional course in ecology for the non-biology major. Environmental ethics or environmental philosophy courses are often offered through humanities or philosophy departments, and courses in environmental literature are available at some institutions. Some universities are attempting to use environmental issues as a campus-wide general education curricular theme.

There are two general approaches for offering a major dealing with the environment. One approach focuses on the natural sciences (environmental biology, environmental chemistry, and/or earth science), and the other focuses on the social sciences and humanities, including public policy, environmental law, and environmental ethics). This report will address those programs that focus on the natural sciences, recognizing the importance of the social sciences and humanities as integral parts of any interdisciplinary environmental science program.

Undergraduate environmental science programs prepare students for careers in environmental science, train individuals to perform research to gain a better understanding of our environment, and to solve environmental problems. Graduates of environmental science programs have begun to make significant contributions. For example, the Grand Canyon Winter Intensive Haze Study which was recently cited by the National Academy of Sciences for "significant, original contributions to our understanding of atmospheric processes" was planned and carried out by scientists who earned their undergraduate degrees in environmental science in the late 1970s. Many graduates from environmental programs are currently working with utilities to improve the nation's air quality, industrial firms to insure compliance with emission requirements, as scientists and educators at colleges and universities across the country, with state, local and the federal governments to establish and enforce environmental standards, and as members of multidisciplinary teams doing consulting work at the local, national and international levels.

Undergraduate environmental science programs also provide experience and establish role models for working in an inter-disciplinary setting. Students involved with these projects have a better understanding of science outside their own academic discipline, and develop the management experience and personal skills prerequisite to working in a team environment.

Environmental education occurs outside the classroom for much of society through visits to museums, zoos, aquaria, botanical gardens, state and national parks, through efforts by civic groups and public service organizations, and through the writings of journalists who specialize in environmental issues. Public television and National Public Radio frequently feature coverage on environmental topics, and the commercial networks occasionally run documentaries on environmental topics. Some of the writers and producers of these educational activities have participated in undergraduate environmental programs and chosen to use their environmental training to interpret for the general public. Undergraduate environmental science programs have been a basis for the increasing level of consciousness and understanding of environmental issues among the American populace.

Evidence for the impact these programs have had in the United States includes the following examples. Many states now have legislation requiring environmental issues to be taught at some level in the K-12 curriculum. There are recycling bills already on the books in many states, counties, and municipalities, and are being considered in others. Most states now prevent the disposal of tires, automobile and household batteries, used automobile oil, agricultural chemicals and toxic substances in landfills.

People are willing to support environmental issues financially, which is often a good indicator of their sincerity. Consumer interest for "green products" is growing, and at the corporate level, some companies are becoming more sensitive to environmental concerns. For some, it has become a major public relations tool.

Over the past twenty years, individuals have devoted thousands of hours of time and labor to improve wetlands, streams, and wildlife habitat through many organizations. The public is aware of the need for protection of pristine areas, and supports organizations which focus on environmental quality and wilderness preservation. Membership in mainstream environmental organizations has increased significantly in the past twenty years and is now at an all-time high for most.

Improvements in the U.S.

On the whole, the contribution of environmental programs has been significant - contributing to progress in many areas, yet failing in others. In the category of successes, environmental education has become more comprehensive and has been infused at all levels of formal (K-12, higher education) and non-formal education (extension services, continuing education, nature centers, etc.). Progress has been made in some aspects of air quality, surface water quality, protection of endangered species and wetlands, recycling and solid waste management. However, while we have some new and expanded parks, wilderness areas, and wild and scenic rivers, other wilderness areas are diminishing, and the quality of many parks is declining. Greater efforts should be directed towards issues including but not limited to: conservation of biodiversity and of wetlands; management of water quality problems in a comprehensive watershed basis, including groundwater; management of toxic wastes; and energy, population and transportation policies. The last category of problems is the result of national policies and programs based on political compromise rather than on sound scientific and technical information. This has been manifest in the past decade in a number of poor national environmental policies such as: our failure to sign the Antarctic and the Law of the Seas Treaties; withdrawal from international population programs; our failure to develop an effective acid rain program; our failure to properly manage toxic and radioactive wastes; the lack of an effective energy policy or policy on the problem of global warming.

Future Trends

Many of the existing environmental problems will need to be addressed in the near future - either proactively, with the efficiencies of prevention, or reactively, with the high economic and external costs of remediation. The need is particularly great in energy policy, endangered ecosystems (e.g. rain forests and wetlands), population control, and the protection and provision of resource bases (e.g. groundwater).

Seven additional issues or trends seem particularly important:

1. Linking of conservation, development, and human rights issues (e.g. women, poor, minorities, developing world concerns) around a central theme of sustainability, ecological integrity and quality of life.

2. Increased information and access created by the mass media and improved communications.

3. The internationalization of the environmental movement to "think globally - and act globally." This will include increased professional opportunities for international travel and collaboration of faculty, an increasing number of international students, and will foster international cooperation to resolve common problems and reduce economic exploitation. Global issues which interweave social and environmental issues include transboundary pollution problems, worldwide loss of habitat and biological diversity, overpopulation, and the relationships among health, poverty, and environmental quality.

4. Avoiding small probability events with potentially catastrophic consequences - caused by accident or intention (e.g. warfare, terrorism). Examples include nuclear or bio/chemical warfare, power plant accidents, transportation accidents (e.g. pipelines, supertankers, toxic spills), and industrial accidents.

5. A wider array of tools will be available to society for the management of environmental problems. In addition to the conventional regulation and enforcement approach, new initiatives involving economic incentives and disincentives, negotiation, mediation, and arbitration will be attempted.

6. An undergraduate university liberal arts degree will require a strong environmental science/studies component. In addition to conventional studies of human social relationships, students will be required to study human/environment relationships, especially our place in the natural world and our impacts on it.

7. Research skills and tools for analyzing environmental problems will become more sophisticated. For example, increased sophistication and availability of computer hardware and software resources will facilitate advances in areas such as geographic information systems. Advances in decision theory and risk assessment, and the development of user-friendly decision support systems will enhance environmental decision-making.

CURRICULUM

Because of the interdisciplinary nature of the field, a student wishing to major in environmental science must have solid integrated coursework in a variety of areas covering the natural sciences, social sciences, and humanities as they relate to the environment. Since the field has no *a priori* affinity with any of the traditional disciplines (e.g., biology, chemistry, or geology), it makes sense to offer the major as a separate program, rather than as a part of those traditional departments.

From the perspective of the student entering the job market, there is a growing demand for a degree in environmental science/ studies to fill positions ranging from entry-level technicians to those requiring a Ph.D. Many potential employers desire a person with an interdisciplinary background that is broader in scope than is available from more "traditional" science majors. (This point was made clearly by the panel on employment opportunities, which follows in the Appendix.)

Graduate vs Undergraduate Programs

We believe that an undergraduate degree should be offered at institutions throughout the United States for the following reasons:

1. Graduates of environmental science programs are often more qualified than graduates of "traditional" majors for employment in a number of settings, including: local, state, and national governmental agencies, consulting firms, non-profit advocacy organizations, and private industry. Environmental science programs should imbue their students with subject matter, critical thinking skills, problem-solving skills and a "world view" that is especially helpful in fulfilling the demands of those employers as well as promoting improvements in environmental quality.

2. For those students wishing to pursue advanced degrees, graduates of environmental science programs would be especially well prepared to enter fields such as Environmental Law, Environmental Management, Environmental Health, Environmental Chemistry, Environmental Biology, and Environmental Journalism. There is a need for skilled researchers in the environmental sciences, provided by education at the graduate level. The broad nature of an undergraduate program in environmental science is especially valuable, considering the typically specialized nature of graduate programs.

3. In addition to providing skills for employment or future study, environmental science programs provide students with a way to satisfy their intellectual curiosity about environmental issues. An initial burst of interest during the environmental movement of the early 1970s was followed by a period of apathy, environmental issues are once again at the forefront of student attention. Representing the best tradition of a liberal arts education, this awareness has translated into a demand for integrated programs focusing on those environmental problems and their solutions. A side benefit is that the program may enhance the overall reputation of the institution and make it more attractive to high quality science students.

4. Faculty and students of undergraduate environmental science programs are often called upon to provide expertise toward solving local and regional environmental problems. Moreover, undergraduate institutions provide interns for governmental agencies and private industry (and those interns benefit from the internship experience, as well). This community service role is especially important in many regions of the U.S. that lack a local graduate-degree-granting institution. Thus, an undergraduate institution with an established environmental science program can be an extremely valuable community resource.

5. Many states are mandating that environmental science be an integral part of the elementary and secondary education curriculum. Thus, teachers must be qualified to address those areas adequately. It falls to an undergraduate environmental science program to develop and implement a curriculum that would provide a sound and current foundation for training those teachers. Many older and mid-career teachers have little or no training in environmental issues.

Course Work

In considering the issue of what courses should be required in environmental science curricula, we recognize that defining a menu of required courses is difficult because institutions are very diverse. In addition, many institutions might not have sufficient resources to meet all of those requirements, but instead might seek to develop their curricula to match existing strengths.

Nevertheless, we agree that certain subject material should be included for the major to effectively prepare its students to be competent environmental scientists:

Ecology/Environmental Biology
Environmental Chemistry
Earth Science/Physical Geography
Environmental Policy, Planning, Law
Environmental Ethics

We also recommend that the following areas be included whenever possible:

Environmental Measurements and Monitoring
Field-oriented Experience
Internships, Cooperative Ed. experience / research

We also expect that a graduate of an environmental science program will have requisite quantitative skills and communicative skills that would be acquired through both the environmental science courses themselves, and the general education requirements of the institution.

PROGRAM STRUCTURE

No single institution can cover all aspects of environmental problems. Therefore, institutions should clearly define the mission of their programs. Further, a program should strive to meet the needs of students and employers in keeping with its overall educational philosophy.

Environmental problems are commonly understood to be interdisciplinary. However, with finite time available, attention to breadth necessarily limits attention to depth in a specialty. Environmental programs must, therefore, balance depth and breadth of curricular requirements appropriate to their mission. The tension between breadth and depth in the curriculum will always be a factor in interdisciplinary programs. Nevertheless, environmental scientists must have depth in a focused discipline such as biology, chemistry, geology, etc. Therefore, students must be advised of the need for assuming rigorously comprehensive course schedules in excess of minimal requirements of most curricula. Programs may provide depth through different tracks within the environmental science major (e.g. environmental biology, environmental geology, resource management, etc.).

Balance of depth versus breadth may depend in part on an astute choice of general studies courses or selection of a limited number of electives from a list of appropriate courses. In this situation, advisement of students is critical in selecting courses and helping them to meet their goals.

Environmental programs must emphasize not only course content, but such skills as oral and written communication, computer skills, critical thinking, ethical decision-making, etc. Critical thinking skills include knowledge, comprehension, application, analysis, synthesis, questioning techniques, problem solving, and evaluation. In part because of difficulty in transfer of

knowledge from traditional courses into the major courses, it is important that environmental science faculty intentionally infuse their courses with activities that foster acquisition of these skills. This may be done in a variety of ways. For example, in introductory environmental science courses or in senior seminar or capstone courses. These skills are also fostered in courses with a strong experiential component.

Students should be able to recognize and define a problem, collect, organize and interpret data, identify strong and weak arguments, develop and evaluate alternative solutions to a problem. Courses can also be designed to incorporate techniques of oral and written communication as a means to learn course content and facilitate critical thinking. Therefore, implementation of diverse teaching methods that promote active, as opposed to passive learning, and that accommodate different learning styles of students are to be recommended.

We recommend that each program design a strategy of incorporating experiences of increasing intensity over the undergraduate's four year career. These experiences should require increasing levels of responsibility and increasing levels of critical thinking, synthesis, etc. For example, early courses might focus on acquisition of technical skills in laboratories. Later experiences might involve application of these skills to problem solving in real life settings. Experiences must force the students to choose and evaluate procedures and determine types of data which are required for problem analysis. They must allow for the possibility of "mistakes" and allow for the students to profit from these "mistakes." Much of the success of these experiences depends on the effectiveness and dedication of the individual instructors or internship supervisors.

The value of internships, student research, field trips and other forms of experiential learning seems to be universally recognized, although perhaps it needs to be emphasized strongly because institutional support for even traditional laboratory components of science courses may be eroding. It is also recognized that experiential courses may compete for time with traditional courses; that is an issue to be resolved by each program.

The development of a strong internship program should be pursued. Internships should not be restricted to narrow, repetitive activities, but should expand the students' knowledge and skills in a challenging manner. Travel experiences combining experiential learning and research, such as offered by the School for Field Studies, are considered particularly valuable.

STUDENTS

Students in environmental science/studies programs represent a typical cross section of our colleges with respect to ability and background. They are often more enthusiastic about their major than many of their classmates because they feel a real commitment to *do* something about environmental issues. As discussed by the panel, the number of minority students going into environmental fields is disappointingly low, despite the fact that minorities are often disproportionately affected by poor environmental quality. Greater numbers of women are becoming interested in the field at the undergraduate level, but they are still underrepresented in many graduate programs.

The number of students in environmental science has increased rapidly over the last few years. The popularity of the major has expanded much faster than have resources to support it. Swelling enrollments call for a greater variety of courses, more teachers in both traditional and new subjects, more opportunities for field experience, and increased administration, especially in curriculum development and placement.

Current predictions indicate an upcoming shortage of trained scientific personnel, and we are concerned that current enrollments may not fill immediate needs for environmental workers. The extent of environmental problems

argues strongly for the need for more human resources in the area. More support should be provided for graduate programs in environmental science to provide excellent researchers for the future.

The proportion of our students that enter graduate school is highly variable from one undergraduate school to another. Their success varies as in other disciplines. Students from more rigorous programs benefit not only from their more extensive background, but also from their better preparation for the pace and expectations of graduate schools. However, ES graduates may be at a disadvantage with regard to success on the Graduate Record Exam (GRE), which is only offered in the traditional disciplines. However, we hesitate to recommend that the Educational Testing Service develop an examination in ES, since ES programs are and will continue to be quite variable in course content.

A significant number of our graduates seek further education in the social sciences -- politics, economics, and law. The extent and perceived value of course work in natural sciences for social scientists (and conversely, in social science for natural scientists) varies widely. Teaching is another career that attracts increasing numbers of our students -- but not enough.

We estimate that over 50% of the students who enter the job market immediately upon graduation are successful in finding employment in an environmentally-related position. Curricula in environmental science provide a multidisciplinary or interdisciplinary approach and give students insights and skills to assess environmental problems and alternative solutions. This facilitates their participation in team efforts used by most employers. Opportunities for advancement with only a Bachelor's degree are somewhat limited, but many employers will support further training of good workers. There are far more opportunities available to students with a Master's degree.

ADMINISTRATIVE ARRANGEMENTS, SUPPORT & REWARDS

In order for environmental program to be successful, it must have enough administrative autonomy to provide for dedication of resources to the program, a sense of community and identity among students, effective communication among faculty, and an appropriate faculty reward system.

While the interdisciplinary and problem-solving aspects of environmental issues may be obvious to many environmental professionals and educators, support for interdisciplinary environmental programs at universities has often been equivocal The environmental field is not fully accepted by all members of traditional disciplines within the university community. Many programs exist more as a consequence of the dedication and expertise of those few faculty directly involved in the programs than because of strong administrative or collegial support.

Given the variety of institutions in higher education and their unique histories, there is no "best" institutional arrangement for environmental science/studies programs. Programs often represent compromises based on historical opportunities, available resources, and institutional traditions.

There are four models for administrative arrangements in general use. The reader should not construe these models as exact replicas of any existing programs, but to use them as a means for identifying outlines of alternative administrative arrangements. We feel that any of these models could be implemented in some fashion at any institution, regardless of the institution's size, or its particular emphasis on teaching and research.

These models are:

Model 1 - Traditional departmental status

Model 2 - Interdisciplinary program structure with contractual arrangements for teaching responsibilities

Model 3 - Interdisciplinary program structure with voluntary faculty participation

Model 4 - Program housed within existing departments

Model 1. Traditional Departmental Structure

In this approach, the ES Program is organized as a traditional department. The ES faculty are members of the department (although there may be some split appointments) and the department is responsible for initiating all personnel decisions, including those for hiring, promotion, and tenure. The budget for the program is under the control of the department chair. Curriculum and administrative responsibilities reside with the departmental faculty. Although the curriculum may include courses in other departments (cross-listed), these departments do not have direct input on decisions for staffing and curriculum design. Departmental status probably provides the best chances for developing a strong program.

Advantages of this structure are:

1. All major elements of the program are under the departmental faculty's control.

2. Faculty are clustered in a common physical location, thus promoting the type of collegial interaction which is important in generating teaching and research ideas.

3. A new faculty member's programmatic responsibilities are within his/her departmental home, thus providing protection when promotion and tenure decisions are made.

4. Students have a "real home" and sense of identification.

Disadvantages of this structure are:

1. This model may be difficult to implement at some institutions, primarily because of the needs for new faculty and facilities in a time of tight budgets, as well as fear of losing some students from existing departments to a new departmental major.

2. This model may be expensive and not cost effective if it results in the duplication within the institution of faculty expertise and courses.

3. Implementation of this model may rely heavily on split faculty appointments, which may be disruptive.

Model 2: Interdisciplinary Program Structure with Contractual Arrangements for Teaching Responsibilities

In this model, all the faculty who participate in the program have their full appointments in disciplinary home departments, yet are contractually obligated to teach a certain number of classes each year to support the Environmental Science program's curriculum. This differs from a program comprised of faculty with split or joint appointments because the obligations to the program in this model do not necessarily include administrative service, research, or student advising.

The advantages of this model include:

1. The program can draw from a wide range of disciplines in a cost-effective manner because advantage can be taken of existing faculty interests.

2. The curriculum has stability because the program has control over some of the faculties' teaching responsibilities.

3. Greater research and teaching innovation may result from the participation of a diverse group of faculty in a single interdisciplinary program.

The main disadvantages are:

1. All elements of program operation other than teaching, including student advising and administration, must be provided by faculty on top of their full responsibilities in their home departments. This may lead to divided loyalties, greater-than-average professional responsibilities, and a risk to faculty during decisions for promotion and tenure.

2. Uncertainty as to who controls the budget and decisions on faculty time/space as the program grows.

Model 3: Interdisciplinary Program Structure with Voluntary Faculty Participation

This model consists of a free-standing program with no contractually assigned faculty. All faculty participation is based on a faculty member's interest in contributing to the program while at the same time attempting to fulfill the responsibilities in her or his home department. In such an arrangement, there may well be courses designated as ES courses. This system or model is only as effective as the director or coordinator of the program because she or he must persuade department heads to allow interested faculty to contribute to the program. Participating faculty are then expected to serve on committees, teach courses, assist in designing curricula, serve as academic advisors for ES students, and perhaps represent the ES program in university governing bodies.

Advantages of this model are:

1. This model is relatively easy to implement in a cost-effective manner.

2. Existing courses and resources can be used in part or whole to support the curriculum.

3. It provides a basis for interdisciplinary cooperation similar to model 2.

Disadvantages of this model are:

1. It is fragile because it is strongly dependent upon the personal commitments of the participating director, faculty, department heads, and deans. Personnel changes in these positions can have a major impact on program stability.

2. It depends on volunteerism and on cooperation among administration and faculty to maintain a coherent program. These may be highly variable from year to year.

Model 4: Programs Housed Within Existing Departments

This is the most diffuse of the models we have identified. Under this system, one or more majors at an institution identifies a set of required and elective courses that constitute a "track", "emphasis" or "concentration" in ES. Such a system does not necessarily include oversight or coordination campus-wide, or even within a division. Each department may act independently, with, for example, a biology major having a concentration in ES, a geology major having a concentration in ES, etc. A track in one department would normally require specific cognate courses offered in other departments.

The advantages of this model are:

1. The graduates of the "tracks" have degrees in traditional disciplines, but with a recognizable course emphasis in ES.

2. Faculty loyalties are not divided, but remain tied directly to home departments.

3. This model can be implemented at low cost, assuming the presence and use of existing resources.

The disadvantages of this model are:

1. It risks lack of coherence, with different standards among departments. In effect this model does not result in an integrated "program" so much as merely providing a vehicle for "environmental literacy" within a discipline.

2. If the tracks are dependent on existing courses for breadth, each track is fragile. Should a key faculty member in one department leave, the tracks in others could be gutted.

3. There is a danger that an ES program housed within an existing major or department will not provide the type of multidisciplinary perspective which is vital in addressing environmental issues, and students may lack a real identification with ES.

A somewhat stronger version of this model is one in which there is a campus-wide director with a multi-disciplinary steering committee, drawn from each department offering such an ES track. This could provide greater coherence and create more uniformity of standards across tracks.

Support Structures

Because of their interdisciplinary nature, ES programs may require new or modified support structures beyond those required for traditional majors. In order to overcome the tendency to think that ES programs can be "added on" without cost by using existing courses, mechanisms must be available to accommodate the special needs of interdisciplinary programs.

Consistent, reliable financial support must be available and specifically designated for ES activities. While a minimal supplies and expenses budget is essential, additional monies to support student and faculty activities related to ES will contribute to a sense of identity and importance for program participants. In order to minimize competition with traditional majors and not undermine interdisciplinary efforts, this funding should not be subject to diversion to other programs. Administrators need to recognize that time (several years) is required to build up a quality ES program. Thus, a long-term commitment to provide the necessary resources must be made; a commitment of one or two years is inadequate.

Closely related to financial support is the academic reward system for faculty. Such a system should be structured to encourage participation and innovation in ES programs. Financial support or release time should be provided for new course development, attendance and presentations at interdisciplinary conferences, and administration. When team teaching is involved, it must be recognized that such activity is more than just dividing course time, and a two-person team will require more than just half a course each to do an effective job of coordination and planning. Faculty responsibilities toward ES programs must be clearly articulated and understood by all parties involved. Some mechanism must be in place to insure that participating faculty cannot be penalized by their department for their involvement when it comes time for tenure and promotion decisions.

Departments and administrators must also recognize that not all courses in ES programs will fit into traditional disciplinary categories. College faculty and administrators must be willing to accept new designations for courses (e.g., "environmental science") and increased flexibility in course titles and content. This implies that there must be a recognized mechanism by which such courses can be developed and approved outside of the traditional departmental structure.

Existing ES programs exhibit a wide range of forms and support structures. None of these is universally "ideal," although the departmental structure appears to have the greatest chance of success. It is very likely, as well, that ES programs will be hybrids of the models we have presented. With this in mind, we make the following recommendations for any institution considering a review of or development of an ES program. We emphasize particularly programs which are structured along the lines of Models 2, 3, or 4. Programs structured according to Model 1, the independent department (which is desirable but rare) often have built-in protections not available to other types of programs.

All programs, regardless of structure, must have strong faculty and administrative support. The rationale, objectives, and expectations for the program must be clearly articulated and well known to participating faculty and the institution at large. A program coordinator or director, with the same standing as traditional department chairs, should be appointed (where Model 1 is not followed). Such a person should be independent of supervision by any one department. The program should have its own operating budget for supplies and expenses. This budget need not include salary lines for participating faculty, but it is critical that the program's operation not come at the expense of other departments.

Expectations for participating faculty must be clearly stated and well known to participants and potential evaluators. Mechanisms must be available to protect against bias toward interdisciplinary work which may develop within more traditional departments when it comes time for tenure or promotion decisions. Such mechanisms must include input from the ES Program into departmental decisions about participating faculty, and ES membership on college-wide promotion and tenure committees. If tenure and promotion decisions are heavily based on recommendations from traditional departments, some oversight mechanism must be available to evaluate and possibly correct for any bias.

EXTERNAL FUNDING

Federal support for undergraduate environmental programs has been nominal compared to the problems and the needs of society. Some funding has been traditionally available from the National Science Foundation, Environmental Protection Agency, and Department of Energy. This is often temporary, piecemeal, and specifically targeted funding - which is difficult to rely upon to build strong, consistent programs. The striking lack of federal leadership and coordination in the area of college level environmental education has been a significant barrier to program development.

More federal support is greatly needed to build strong professional environmental programs in U.S. colleges and universities. Curricula that prepare students for research or monitoring using sophisticated technical equipment are particularly vulnerable to inadequate funding, and instruments available in disciplinary programs may not be available to faculty and students in ES. Universities should have adequate funds to purchase and maintain scientific equipment on behalf of students in all the sciences, including Environmental Sciences. Additional resources, consistently available from the EPA, DOE, and NSF would be most useful in program development. In addition, funding for environmental education programs from the Department of Education is forthcoming and most welcome. We hope that this will not focus exclusively at the pre-college level.

Greater attention to the interdisciplinary environmental sciences, both in the research divisions and in the undergraduate education division of NSF, and the development of a "National Institutes for the Environment" (NIE) are also ideas with considerable merit and worth pursuing. The committee of the National Academy of Sciences that is studying the state of research support for the environmental sciences and the possible need for an NIE ought to consider the state of funding for college level environmental education as well.

Some funding for environmental science programs (mostly for research and curriculum development) has come from foundations, utilities, and industry. In the future, it is anticipated that increased cooperation between the academic and business community will provide additional resources for program development.

SUMMARY AND RECOMMENDATIONS

- ES programs have had a national impact, in terms of our awareness of environmental issues and in the training of professionals with the expertise to work on solving complex cross-disciplinary environmental problems.

- ES graduates must have an interdisciplinary perspective, but must also have adequate depth in one of the technical areas, as well as a grasp of policy and ethics. This will require rigorous course schedules and careful advisement by concerned faculty.

- ES graduates need to have analytical and problem-solving skills, computer skills, critical thinking, and oral and written communications skills. These may be acquired within ES courses, and from other departments.

- ES programs should provide experiential activities through field work, internships, or research experiences.

- While there are a number of administrative arrangements that can be effective, any program, to succeed, must have strong faculty and administrative support. A program director should have autonomy and his or her own operating budget. Mechanisms must be in place to protect faculty from bias against interdisciplinary work when promotion and tenure decisions are made. These conditions are met most often with a departmental structure.

- Funding from the federal government has been small relative to the current scope of environmental problems and the needs for trained professionals to solve them. Federal support is essential to build strong professional programs supported with modern scientific equipment. The lack of federal leadership in this area has been a significant barrier to program development. The new National Academy of Sciences committee looking into the state of the environmental sciences should also consider the state of federal support for educational efforts for producing environmental scientists.

APPENDIX

Remarks by the Employment Opportunities Panel:

Philip Dorn, of Shell Development Company stated that for the few opportunities available at the Bachelor's degree level, engineering, chemistry, and mathematics skills were considered essential, in contrast to environmental biology. Other essential traits are: technical ability, communications skills, and the ability to be a "team player."

P. A. Buckley of the National Park Service stressed that while many people start out working in environmental science, most eventually go into administration in order to advance in their careers. A typical job for an ES graduate would be as a Resource Management Specialist, which starts at the GS 5-7 level, and may go as high as GS 13. Abilities considered desirable include literacy, communication skills, training in statistics and geographical information systems (GIS); field experience; and basic computer skills. He stressed the desirability of knowledge of "natural history," and mentioned that one good way to start a career in the Park Service is through seasonal employment.

Louis Pitelka of the Electric Power Research Institute, speaking from the perspective of the utility industry and consulting firms, pointed out that employees need to know basic science fundamentals and have depth in a specific field. Also very important are oral and written communications skills and basic computer skills. While large organizations employ specialists in different fields, small utilities and consulting firms need more generalists, a niche potentially well filled by ES graduates. He urged that rigorous science be the core of ES programs.

Ronald Slotkin of the Environmental Protection Agency pointed out that the agency has 12 laboratories employing 2,000 people, as well as employees who work for contracting organizations. A specific field expected to grow rapidly is bioremediation. There are many technician positions, from which individuals can move into regional offices to diversify their experience. He urged colleges and universities to develop a relationship with a nearby laboratory or regional office.

Frances Sharples of the Oak Ridge National Laboratory spoke about opportunities within the Department of Energy, which has a large number of scientific and technical employees as well as those employed by contracting firms. DOE will hire many new environmental scientists in geology, engineering, hazardous waste management, risk assessment, soil science, as well as in policy and law. Individuals will need high grades as well as technical expertise and/or broad background, good communications skills and abilities to talk with people from diverse disciplines.

V.J. Smith of the Environmental Defense Fund (EDF) indicated that her organization tries to link science and law to reach innovative solutions to environmental problems. She stressed that most of the scientists employed by EDF are at the Ph.D. level, but that other environmental organizations hire more at the Bachelor's level. Desired characteristics for working in public interest groups (beyond a commitment to the environment) include expertise in a technical field, analytical skills, communications skills, and some background in policy. Advocacy skills and experiences such as internships and volunteer work are also desirable. She stressed the need to bring more minorities into the environmental field.

Kevin Doyle of the CEIP Fund, Inc. described CEIP as an environmental careers organization which runs a program that places recent graduates in paid internships, runs workshops and a National Environmental Career conference. The CEIP has published a highly regarded book, *Guide to Environmental Careers*. The Minority Opportunities Program provides special internships for minority students. He noted that state and local governments have great needs for personnel and that "flexibility" is important to many agencies.

In the discussion which followed the presentation, it was pointed out that those who spoke were, for the most part, representatives of large or major organizations. The needs of such organizations are often quite different from those of grassroots citizen organizations and local government and state agencies which comprise a large and important source of employment for those with bachelor's degrees in ES.

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EDUCATING THE FUTURE ENVIRONMENTAL SCIENTIST
Conference Report Published

The growing complexity of global environmental problems has placed great demands on current undergraduate academic programs. Recognizing the need for expanded, cross-disciplinary approaches, Dr. Judith S. Weis, Professor of Zoology at Rutgers University (Newark, New Jersey), organized a two-day workshop in conjunction with the 42nd Annual Scientific Meeting of the American Institute of Biological Sciences (AIBS) in San Antonio, Texas on August 7 and 8, 1991.

Seven government and industry officials joined two dozen college and university professors to produce a comprehensive report on the current status and future prospects in undergraduate environmental science (ES) education. The report addresses the related aspects of mission and impact, curriculum, program structure, students, administration and funding.

Highlights of the report emphasize the interdisciplinary perspective of ES with a thorough grounding in analytical and problem-solving skills, computer literacy, critical thinking and oral and written communication abilities. Strong faculty and

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administrative support at the departmental level is essential for the success of such a broad based ES programs. Experiential activities thorough field work or mentored research are desirable to establish the nature and approach of an applied science. A limited quantity of the report are available on request from interested journalists.

Funding for the project was provided by the Education Foundation of America, the U.S. Environmental Protection Agency and the Shell Oil Corporation. The report is being distributed to our nation's 3,000 baccalaureate level campuses. Support for the workshop was also provided by Trinity University (San Antonio, Texas) and AIBS.

Founded in 1947 as a component of the National Academy of Sciences, AIBS is now an independent federation of 50 professional societies and research organizations representing 80,000 biological scientists. It is devoted to the advancement of biological, agricultural, medical, and environmental sciences and their applications to human welfare. It also fosters and encourages research and education in the biological sciences, and publishes the monthly journal, BioScience, and the bi-monthly policy analysis report, AIBS Forum. The institute assists such diverse government bodies as the Agency for International Development, the Departments of Agriculture, Commerce, Defense, Energy and Interior, and the space agency NASA by providing expert studies, reviews, evaluations and policy planning in the life sciences.